Draft 8/11/09

4. The Chernobyl Incident and the Initial Response

Now that we've covered a few of the basics about radiation, radioactivity and the types of emergencies that may occur, we can better examine the issues associated with radiological contamination. The 1986 accident at the Chernobyl power plant in the Soviet Union gives us insight into how we might recover from a wide-scale radiological event. First, let's take a look at the accident itself.

In the early morning hours of April 26, 1986, the Chernobyl nuclear plant experienced the worst nuclear power accident in history. The accident created an uncontrolled nuclear reaction and the resulting explosion and fire sent a massive cloud of radioactive material into the atmosphere. The reactor burned for 10 days, releasing radioactive gases, vapors, aerosols and particles, and contaminating thousands of square miles in Ukraine, Belarus, Russia, and Western Europe. *[Images: nuclear technicians at the plant, the plant on fire, people suiting up to respond.]*

The Chernobyl nuclear plant is located near the border between Russia, Ukraine, and Belarus, about 70 miles northwest of the city of Kiev, the nearest major population center. Kiev had a population of about 2.5 million people at the time of the disaster. The town of Pripyat, located about two miles from the reactor, had a population of about 45,000 people at the time of the accident. *[Image – a map showing the broader geographic area, the plant, Pripyat, and Kiev—there is a good one at world-nuclear.org/info/chernobyl.]*

The exact cause of the accident is still uncertain, but it is widely accepted that a combination of reactor design flaws and mistakes made by the plant operators caused the accident. On April 25, plant personnel began conducting a safety test to determine if the reactor's cooling system pumps could operate if the external power failed. The reactor operators disabled an automatic shutdown system and inserted control rods into the reactor's core to create the low power conditions required for the test. However, the power level in the reactor dropped more than anticipated, and the operators tried to increase it by manually withdrawing some of the control rods. Within seconds of withdrawing the control rods, the power level in the reactor shot up to dangerous levels. When the operators tried to reinsert the control rods again, the rods shattered and could not be lowered further into the reactor core to control the reaction. *[Images – reactor personnel, the power plant, and a plant exploding.]*

The cooling water located around the reactor core vaporized within seconds, causing a steam explosion that blew the lid off the reactor. The sudden inrush of oxygen caused a tremendous fire, and the reactor core and building burned for 10 days, releasing more than 100 times the amount of radioactivity into the atmosphere that occurred during the bombing of Hiroshima. Radioisotopes were carried upward into the atmosphere where they traveled with the prevailing winds.

According to reliable reports (*IAEA Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience p.21*, winds were initially to the northwest, but they

varied over the next several days so that all areas were downwind at some point while the fire in the core continued burning. To further complicate matters, scattered thunderstorms and rainfall throughout the area brought down some of the airborne material to ground level, forming an irregular radioactive fallout pattern over thousands of square miles. *[graphic – figure 3.2 IAEA report, image of fallout pattern IAEA report Fig 3.6 and http://www.chernobyl.info/index.php?navID=2]*

The initial response to the disaster was disorganized, improvised, and chaotic. The main priority of the first responders was to put out the fire and then isolate the reactor core. First on the scene were local firefighters and soldiers who were not aware of the grave threat of exposure to very high levels of radioactivity. The firefighters extinguished the fires on the roof of the reactor building and in the surrounding area, thus protecting the other reactors at the Chernobyl facility, but they were not able to put out the burning reactor core. Many of these heroic firefighters and soldiers died of exposure to radiation within days or weeks. *[Image: commemorative statue to lost firefighters in the town of Pripyat.]*

To put out the fire in the core, local authorities tried several approaches, including dropping 5,000 tons of sand, clay, and lead onto the core by helicopter. *[Image: helicopters dropping bags of materials.]* But because of the dangerous conditions and extreme heat, it took workers 10 days to put out the fire.

Although the very first responders did not realize that the reactor was releasing high levels of radiation, the authorities soon recognized that the disaster had exposed the reactor core and ordered evacuation of the surrounding area. The town of Pripyat, located 2 miles northwest (and downwind) of the reactor, was evacuated on Sunday, April 27, one and one half days after the accident began. Residents were told to pack for three days and to leave household pets behind. The motivation for giving such a short timeframe for the evacuation was logistical: to limit the amount of baggage and personal belongings to be transported and to expedite the evacuation. A convoy of 1200 buses carried the residents and their belongings away, and the evacuation was reportedly completed in about three hours. *[Images of the evacuation of Pripyat – the long line of buses, lines of people getting on them and so forth.]*

In the following days, authorities measured radiation levels in the areas surrounding Chernobyl to determine the extent of contamination. Radiation levels above background were measured at distances of hundreds of miles away, but the government focused on the most heavily contaminated areas. The Soviet Ministry of Public Health determined that a 30 kilometer (about 19 miles) radius around the plant site would be evacuated.

Isolating the reactor was an immediate priority once the fires were extinguished and the nearby towns were evacuated. To make a safer work zone, the area surrounding the reactor was cleared of debris. The contaminated debris, reactor core fragments, and surface soils from the immediate area around the reactor were placed in a concrete reinforced gallery hastily constructed around the reactor. Removal and shielding of this material made the area safer to work in.

Other soils and debris were stored in a large number of temporary shallow trenches and impoundments within the exclusion zone and covered with soil to provide minimal shielding and to reduce potential for wind to mobilize the contaminants. These trenches and small impoundments were not designed as permanent storage, yet most of them remain to this day.

[Possible image – trenches around Chernobyl or a generic trench and piles of debris to illustrate concept.]

After cleaning the blast area, a structure known as the sarcophagus was constructed of concrete, steel plates and beams to isolate the most contaminated wastes and the reactor. The sarcophagus was constructed between May and November 1986 under very hazardous working conditions. *[Images of the Chernobyl sarcophagus.]* The structure was hastily designed and erected and has been exposed to the elements and infiltrated by moisture for more than 20 years. A new safer confinement structure is currently being designed to address the shortcomings of the sarcophagus and to isolate the reactor core and the most contaminated wastes for the next 100 years. *[Image: New safe confinement structure image is on cover of IAEA report: Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience.]*